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**ABSTRACT:**

PURPOSE: To miniaturize and lighten a detection mechanism, and to improve the workability of radiation measurement while enhancing spectral sensitivity by combining a photocell with a CsI (TI) scintillator requiring no cryogenic cooling mechanism and high-tension power supply and cooling both the scintillator and the photocell by a small-sized lightweight thermoelectric cooling panel and a radiation shielding body.

CONSTITUTION: A well type sub-detector 2 is arranged so as to surround a core type main detector 1, the single crystal of CsI (TI) is used as a scintillator, and electronic signals are generated by photocells 3 mounted on each end face, extracted to each preamplifying substrate 4, and input to a anticoincidence counter circuit. Thermoelectric cooling panels 5 are stuck on the photocells 3, and the temperatures of the photocells 3 are cooled at 30°C or lower. The heat of the panels 5 is transmitted over radiation shielding bodies 9, 10, 11 through transmission plates 6 at that time, and dissipated to the outside. An anticoincidence counting

method is applied to the two signals extracted from the preamplifying substrate 4, and noises by Compton scattering of  $\gamma$ -ray spectrum are removed, thus improving spectral sensitivity.

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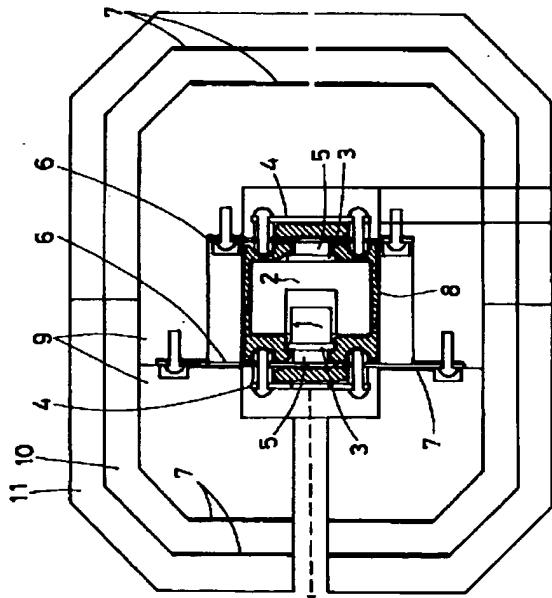
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(54)【発明の名称】  $\gamma$ 線検出装置

(57)【要約】

【目的】 原子炉等の $\gamma$ 線測定において、軽量かつコンパクトで、高温、高バックグラウンドに耐え得る $\gamma$ 線検出装置を提供する。

【構成】 CsI(Tl)シンチレータ1, 2と光電素子3を組合せた主副各検出器1, 2と、これらを利用する逆同時計数回路と、上記各光電素子3に添着されこれらの昇温を抑制する電子冷却パネル5と、上記主副各検出器1, 2と電子冷却パネル5を取り囲むと共に、電子冷却パネル5の放熱を行う放射線遮蔽体9, 10, 11とを備えたことを特徴としている。



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## 【特許請求の範囲】

【請求項1】 CsI(Tl)シンチレータと光電素子を組合せた主検出器と、同じくCsI(Tl)シンチレータと光電素子を組合せ、上記主検出器の周囲と後方とを取り囲むよう配設された副検出器と、上記各光電素子に添着され各光電素子の昇温を抑制する電子冷却パネルと、上記主副各検出器と各電子冷却パネルを取り囲むと共に、電子冷却パネルの放熱を行う放射線遮蔽体と、 $\gamma$ 線の逃散光子を上記主検出器と副検出器とで同時に検出させ、副検出器からのパルスを主検出器からのパルスと逆同時計数する電子回路とを備えたことを特徴とする $\gamma$ 線検出装置。

## 【発明の詳細な説明】

## 【0001】

【産業上の利用分野】本発明は、放射線の一種である $\gamma$ 線のエネルギー別測定をすることによって、放射性同位元素（核種）の検出を行なうエネルギー分散型 $\gamma$ 線検出装置に関するものである。

## 【0002】

【従来の技術】上記 $\gamma$ 線を検出する装置として逆同時計数法を用いたものは従来、ゲルマニウム検出器のまわりにNaI(Tl)検出器等を組み合わせた装置が広く用いられている。またCsI(Tl)検出器と光電素子を組み合わせた検出装置も従来単体で使用されている。

【0003】前者の文献としては“BGOコンプトン抑制スペクトロメーターの性能”(THE PERFORMANCE OF A BISMUTH GERMANATE ESCAPE SUPPRESSED SPECTROMETER FOR EDUCATIONAL USE)等があり、また後者には“教育用ポータブルガンマスペクトロメーター”(PORTABLE GAMMA SPECTROMETER FOR EDUCATIONAL USE)等がある。

【0004】この種の装置として代表的なものは前記Ge半導体検出器を用いたものであるが、これは精度は良い半面、極低温冷却機構と高圧電源が必要なため容積と重量が大きくなり、狭い空間で迅速な作業を要する原子力発電所では設置等に時間がかかる放射線被曝の危惧があった。

【0005】また、前記CsI(Tl)検出器と光電素子を用いた従来の簡易検出装置は、高温で且つコンプトンバックグラウンドが高い原子力発電所の作業現場では精度よく核種を同定できる機能を備えていなかった。

## 【0006】

【発明が解決しようとする課題】本発明は叙上の如き実状に対処し、軽量かつコンパクトで、高温、高バックグラウンドに耐え得る $\gamma$ 線検出装置を見出すことにより、原子力発電所の放射能測定の作業性を改善し、この測定の強化促進を図ることを目的とするものである。

## 【0007】

【課題を解決するための手段】即ち、上記目的に適合する本発明の $\gamma$ 線検出装置の特徴は、CsI(Tl)シンチレータと光電素子を組合せた主検出器と、同じくC

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sI(Tl)シンチレータと光電素子を組合せ、上記主検出器の周囲と後方とを取り囲むよう配設された副検出器と、上記各光電素子に添着され各光電素子の昇温を抑制する電子冷却パネルと、上記主副各検出器と各電子冷却パネルを取り囲むと共に、電子冷却パネルの放熱を行う放射線遮蔽体と、 $\gamma$ 線の逃散光子を上記主検出器と副検出器とで同時に検出させ、副検出器からのパルスを主検出器からのパルスと逆同時計数する電子回路とを備えたところにある。

## 10 【0008】

【作用】上記本発明の $\gamma$ 線検出装置は原子力発電所の定期検査に活用すると効果的であり、この場合、例えば原子炉の1次冷却系配管などの外側から $\gamma$ 線エネルギーを測定して配管内部の核種の量を推定することができる。さらに、定期検査時に配管内部を化学薬品で洗浄したような場合、化学洗浄の前後に本発明による検出器で測定を実施すれば、洗浄の効果を確認することができる。

【0009】これらの測定作業は原子炉停止中に行われるため作業環境の温度と放射線レベルは人間が入れる程度に低下しているが、配管自体は約50°C～100°Cの状態にある時に測定作業を実施しなければならないような場合がある。また、放射線レベルは測定対象が1次系であるか、2次系であるか、あるいは配管であるか機器であるなどにより位置的な差異があり、しかも、原子炉停止後何時間経過したかなど時間的な変化を考慮に入れる必要がある。

【0010】しかして、これら作業環境の位置的時間的差異に対応して、上記本発明によるエネルギー分散型 $\gamma$ 線検出装置は小容積軽量の原則を維持増強することができる。

【0011】即ち、上記本発明の装置においては、検出器として特に極低温冷却機構や高圧電源を必要としないCsI(Tl)と光電素子の組合せを用いると共に、小型軽量の電子冷却パネルと放射線遮蔽体を利用した放熱システムの採用によって、装置末端の検出機構を軽量かつコンパクトに形成することができる。また、上記本発明のCsI(Tl)シンチレータの光電素子は比較的高い温度でも作用しうるものであり、さらには、逆同時計数電子回路によりコンプトンバックグラウンドを低減せしめて $\gamma$ 線の検出を精度良く行わしめることが可能である。

## 【0012】

【実施例】以下さらに添付図面を参照して、本発明の実施例を説明する。

【0013】図1に示すものは本発明の一具体例であって、原子力発電所の定期検査に適用するための配慮をほどこした $\gamma$ 線検出機構の実施例である。この実施例の検出装置は、図1に示す装置末端の $\gamma$ 線検出機構と図2に示す逆同時計数法の電子回路とを備え、上記 $\gamma$ 線検出機

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構の概略寸法は長さが約13cmで直径が約10cmである。

【0014】まず、放射線検出と冷却の構造を説明する。図において1はコア型CsI(T1)主検出器であって、材質はCsI(T1)の単結晶をγ線に対するシンチレータとし、その端面に光電素子3のシリコンフォトダイオードを装着して電気信号を発生させるものである。2は同じくCsI(T1)検出器であるが、その形状は上記主検出器1の周囲と後方を取り囲むウェル型の副検出器となっている。これらの検出器1, 2から出る電気信号は各々の前置增幅器基板4に入り、図2に示す逆同時計数回路へと進む。

【0015】一方、光電素子3には既知の構造の電子冷却パネル5が張り付けられており光電素子3の温度を30°C以下に冷却することができる。

【0016】次に放射線遮蔽及び放熱の諸構造について説明する。放射線遮蔽体9, 10, 11は鉛の筒体であり、伝熱プレート6を介して電子冷却パネル5の熱を放熱する作用を兼ねる。伝熱プレート6と放射線遮蔽体間に熱伝導のよいインジウムフォイル7が貼られている。放射線遮蔽体10, 11は、環境放射線の強度により脱着可能であり、低線量率の場合、これらを取り外すことによって、さらに軽量化が図れる。

【0017】なお、図中12は検出用のコリメータ、13は配線(図示せず)を外部へ引き出すための孔、また8は断熱体を夫々示している。

【0018】さらに、図1に示した構造がどのような作用を果たしているかを以下に説明する。シンチレータをコア型CsI(T1)主検出器1とウェル型CsI(T1)副検出器2に分割し、その端面に各々光電素子3(フォトダイオード)を装着し、それぞれの電気信号を2個の前置增幅器基板4に取出し、両信号に対して逆同時計数法を適用する。この逆同時計数法は、γ線スペクトルのコンプトン散乱によるノイズを除いてフォトピークだけを鮮明に引出し、検出器のスペクトル感度を向上させる手法として知られているものである。図1に示した構造は、極めて小容積軽量の構造によって、この手法を適用できるようにした点に基本的な特徴がある。主検出器1に入ってコンプトン散乱し、副検出器2に入って検出されたγ線は同時に副検出器2系へ信号パルスを与えるので、逆同時計数電子回路はこれを判別して除去する。このような信号処理を行なう逆同時計数法の実施例の回路ブロック線図を図2に示す。

【0019】一方、電子冷却パネル5の作用は光電素子3を冷却して30°C以下に保つことである。30°Cを越えると光電素子3にノイズが発生し、検出能力が低下す

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る。即ち、原子力発電所の定期検査時の作業環境では40~50°Cになる場合がありうるので、光電素子3を冷却することが必要な条件となってくる。本発明ではこの電子冷却パネル5の使用によって極めて小容積軽量に光電素子の冷却を達成できることが明らかである。

【0020】また、図1に示す放射線遮蔽体9, 10, 11は、一体となって放射線を遮蔽すると同時に、電子冷却パネル5の放熱作用を伝熱プレート6を介して行なっている。このように遮蔽体を放熱に利用することは小容量軽量化に役立っている。さらに放射線遮蔽体10, 11は撤去・組み合わせが、かなりの自由度をもって放射線測定環境に応じて選択できる。

【0021】

【発明の効果】以上説明したように、本発明のγ線検出装置は、CsI(T1)シンチレータと光電素子を組合せた主副各検出器と、これらを利用する逆同時計数回路と、上記各光電素子に添着され各光電素子の昇温を抑制する電子冷却パネルと、上記主副各検出器と電子冷却パネルを取り囲むと共に、電子冷却パネルの放熱を行う放射線遮蔽体とを備えたものであり、検出器として特に極低温冷却機構や高圧電源を必要としないCsI(T1)と光電素子の組合せを用いると共に、小型軽量の電子冷却パネルと放射線遮蔽体を利用した放熱システムの採用によって、装置末端の検出機構を軽量かつコンパクトに形成することが可能で、また、上記CsI(T1)シンチレータの光電素子は比較的高温環境でも使用することができ、さらに上記逆同時計数回路によりコンプトンバックグラウンドを低減しγ線の測定分解能を良好ならしめて、原子力発電所の放射能測定の作業性を改善しこの測定の強化促進を図るとの顕著な効果を奏するものである。

【図面の簡単な説明】

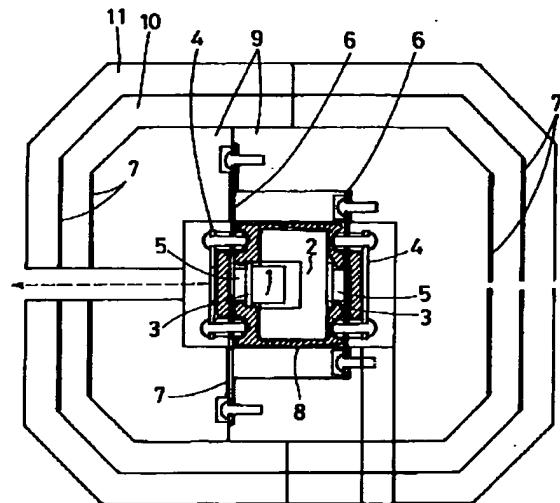
【図1】本発明実施例のγ線検出装置の検出機構を示す断面図である。

【図2】同実施例の逆同時計数法の回路ブロック線図である。

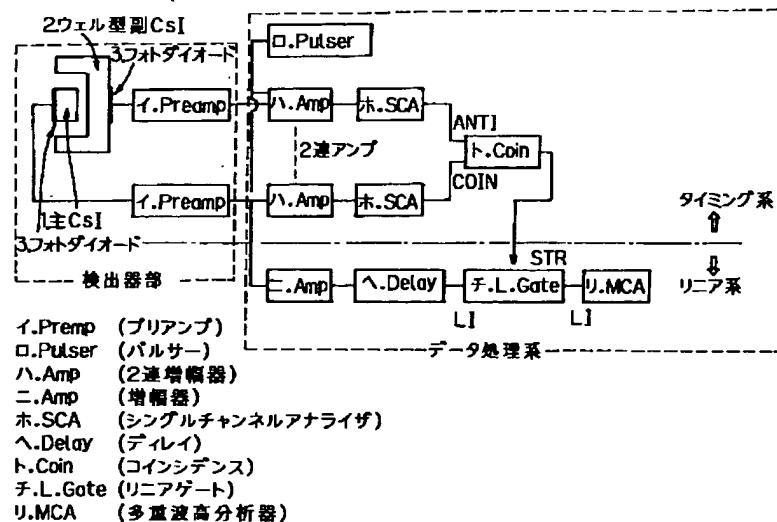
【符号の説明】

- 1 主検出器(CsI(T1)シンチレータ)
- 2 副検出器(CsI(T1)シンチレータ)
- 3 光電素子
- 4 前置増幅器基板
- 5 電子冷却パネル
- 6 伝熱プレート
- 7 インジウムフォイル
- 8 断熱体
- 9, 10, 11 放射線遮蔽体

【図1】



【図2】



フロントページの続き

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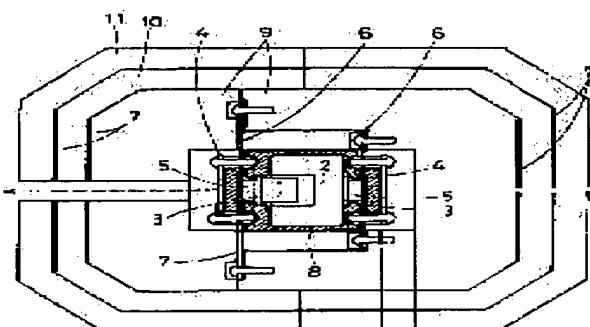
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MASATAKA  
SHINTANI  
HIROFUMI

## (54) GAMMA-RAY DETECTOR

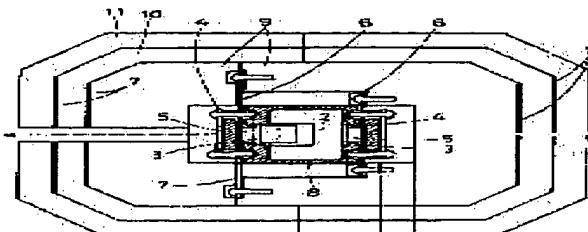
## (57) Abstract:

PURPOSE: To miniaturize and lighten a detection mechanism, and to improve the workability of radiation measurement while enhancing spectral sensitivity by combining a photocell with a CsI (TI) scintillator requiring no cryogenic cooling mechanism and high-tension power supply



and cooling both the scintillator and the photocell by a small-sized lightweight thermoelectric cooling panel and a radiation shielding body.

CONSTITUTION: A well type sub-detector 2 is arranged so as to surround a core type main detector 1, the single crystal of CsI (TI) is used as a scintillator, and electronic signals are generated by photocells 3 mounted on each end face, extracted to each preamplifying substrate 4, and input to a anticoincidence counter circuit. Thermoelectric cooling panels 5 are stuck on the photocells 3, and the temperatures of the photocells 3 are cooled at 30° C or lower. The heat of the panels 5 is transmitted over radiation shielding bodies 9, 10, 11 through transmission plates 6 at that time, and dissipated to the outside. An anticoincidence counting method is applied to the two signals extracted from the preamplifying substrate 4, and noises by Compton scattering of  $\gamma$ -ray spectrum are removed, thus improving spectral sensitivity.



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## CLAIMS

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[Claim(s)]

[Claim 1] The main detector which combined the CsI (Tl) scintillator and the photoelectric element, and the subdetector similarly arranged in the CsI (Tl) scintillator and the photoelectric element so that the perimeter and back of combination and the above-mentioned main detector might be surrounded, While surrounding the thermoelectric-cooling panel which is installed by each above-mentioned photoelectric element and controls the temperature up of each photoelectric element, and the above-mentioned main-sub \*\*\*\*\* and each thermoelectric-cooling panel Gamma ray detection equipment characterized by having the radiation shielding object which radiates heat in a thermoelectric-cooling panel, and the electronic circuitry which is made to carry out coincidence detection of the escaping photon of a gamma ray with the above-mentioned main detector and a subdetector, and carries out anticoincidence counting of the pulse from a subdetector to the pulse from the main detector.

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[Translation done.]

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## DETAILED DESCRIPTION

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### [Detailed Description of the Invention]

#### [0001]

[Industrial Application] This invention relates to the energy dispersion mold gamma ray detection equipment which detects radioisotope (nuclear species) by carrying out measurement according to energy of the gamma ray which is a kind of a radiation.

#### [0002]

[Description of the Prior Art] as the equipment which detects the above-mentioned gamma ray -- anticoincidence -- counting -- the equipment with which the thing using a method combined the NaI (Tl) detector etc. with the surroundings of a germanium detector conventionally is used widely. Moreover, the detection equipment which combined the CsI (Tl) detector and the photoelectric element is also used alone conventionally.

[0003] As former reference, "the engine performance of a BGO Compton control spectrometer" (THE PERFORMANCE OF A BISMUTH GERMANATE ESCAPE SUPPRESSED SPECTROMETER) etc. occurs, and there is "a portable gamma spectrometer for education" (PORTABLE GAMMA SPECTROMETER FOR EDUCATIONAL USE) etc. in the latter.

[0004] Although the thing typical as this kind of equipment used said germanium semiconductor detector, while it was accurate, since a very-low-temperature cooler style and a high voltage power supply were required, the volume and weight became large, this required time amount for installation etc. and it had anxiety of radiation exposure in the nuclear power plant which narrow space takes a quick activity.

[0005] Moreover, the conventional simple detection equipment using said CsI (Tl) detector and photoelectric element was not equipped with the function in which it is an elevated temperature and nuclear species can be identified with a

precision sufficient in the work site of the nuclear power plant where the Compton background is high.

[0006]

[Problem(s) to be Solved by the Invention] This invention copes with the actual condition like the above statement and is lightweight and compact, and by finding out the gamma ray detection equipment which can bear an elevated temperature and a high background, the workability of the radioactivity measurement of a nuclear power plant is improved, and it aims at aiming at promotion of strengthening of this measurement.

[0007]

[Means for Solving the Problem] Namely, the description of the gamma ray detection equipment of this invention which suits the above-mentioned purpose The main detector which combined the CsI (Tl) scintillator and the photoelectric element, and the subdetector similarly arranged in the CsI (Tl) scintillator and the photoelectric element so that the perimeter and back of combination and the above-mentioned main detector might be surrounded, While surrounding the thermoelectric-cooling panel which is installed by each above-mentioned photoelectric element and controls the temperature up of each photoelectric element, and the above-mentioned main-sub \*\*\*\*\* and each thermoelectric-cooling panel It is in the place equipped with the radiation shielding object which radiates heat in a thermoelectric-cooling panel, and the electronic circuitry which is made to carry out coincidence detection of the escaping photon of a gamma ray with the above-mentioned main detector and a subdetector, and carries out anticoincidence counting of the pulse from a subdetector to the pulse from the main detector.

[0008]

[Function] The gamma ray detection equipment of above-mentioned this invention is effective if it utilizes for the periodic check of a nuclear power plant, can measure gamma lineal energy from outsides, such as primary-cooling-system piping of a reactor, in this case, and can presume the amount of the nuclear species inside piping. Furthermore, the effectiveness of washing can be checked, if it measures with the detector by this invention before and after chemical cleaning when chemicals wash the interior of piping at the time of a periodic check.

[0009] Since these measurement is performed during a reactor halt, the temperature and radiation level of work environment are falling to extent which human being puts in, but the piping itself has a case so that measurement may be carried out, when it is in an about 50 degrees C - 100 degrees C condition. Moreover, radiation level has a location-difference by whether the measuring

object is a first order system, or it is the second order system, it is piping, or it is a device, and it is necessary to take time change, such as how many hours passed after the reactor halt, into consideration moreover.

[0010] A deer can be carried out and the energy dispersion mold gamma ray detection equipment by above-mentioned this invention can carry out maintenance enhancement of the principle of a small volume light weight corresponding to the location-time difference among these work environments.

[0011] That is, especially in the equipment of above-mentioned this invention, while using the combination of the CsI (Tl) and the photoelectric element which need neither a very-low-temperature cooler style nor a high voltage power supply as a detector, the detection device of an equipment end can be formed in lightweight and a compact by adoption of the heat dissipation system using a small lightweight thermoelectric-cooling panel and a radiation shielding object. moreover, the thing which can act also at temperature with the comparatively high photoelectric element of the CsI (Tl) scintillator of above-mentioned this invention -- it is -- further -- anticoincidence -- counting -- it is possible to make the Compton background reduce by the electronic circuitry, and to make a gamma ray detect with a sufficient precision.

[0012]

[Example] With reference to an accompanying drawing, the example of this invention is explained further below.

[0013] It is one example of this invention which is shown in drawing 1 , and it is the example of the gamma ray detection device considered for applying to the periodic check of a nuclear power plant. The detection equipment of this example is equipped with the electronic circuitry of reverse coincidence counting shown in the gamma ray detection device and drawing 2 of the equipment end shown in drawing 1 , and die length is [ the diameter of the outline dimensions of the above-mentioned gamma ray detection device ] about 10cm in about 13cm.

[0014] First, the structure of radiation detection and cooling is explained. In drawing, 1 is the core mold CsI(Tl) main detector, the quality of the material makes the single crystal of CsI (Tl) the scintillator to a gamma ray, and equips the end face with the silicon photodiode of a photoelectric element 3, and generates an electrical signal. Although 2 is similarly a CsI (Tl) detector, the configuration serves as a subdetector of the well mold which encloses the perimeter and back of the above-mentioned main detector 1. The electrical signal which comes out of these detectors 1 and 2 goes into each preamp substrate 4, and goes to the anticoincidence circuit shown in drawing 2 .

[0015] On the other hand, the thermoelectric-cooling panel 5 of known structure

is stuck on the photoelectric element 3, and the temperature of a photoelectric element 3 can be cooled at 30 degrees C or less.

[0016] Next, radiation shielding and many structures of heat dissipation are explained. The radiation shielding objects 9, 10, and 11 are leaden barrels, and serve as the operation which radiates heat in the heat of the thermoelectric-cooling panel 5 of 5 through the heat transfer plate 6. Between the heat transfer plate 6 and the radiation shielding object, the good indium foil 7 of heat conduction is stuck. The radiation shielding objects 10 and 11 can attain lightweight-ization further by desorption being possible and removing these with the reinforcement of environmental radiation, in the case of a low-dose rate.

[0017] In addition, a hole for the collimator for detection in 12 in drawing and 13 to pull out wiring (not shown) to the exterior and 8 show the heat-insulating element, respectively.

[0018] Furthermore, it explains below what kind of operation the structure shown in drawing 1 has achieved. a scintillator -- the core mold CsI(Tl) main detector 1 and the well mold CsI(Tl) secondary detector 2 -- dividing -- the end face -- the each photoelectric element 3 (photodiode) -- equipping -- each electrical signal -- two preamp substrates 4 -- drawing and both signals -- receiving -- anticoincidence -- counting -- a method is applied. This reverse coincidence counting pulls out only a photograph peak vividly except for the noise by Compton scattering of a gamma ray spectrum, and is known as the technique of raising the spectral sensitivity of a detector. The structure shown in drawing 1 has the description fundamental to the point which enabled it to apply this technique according to the structure of a very small volume light weight. Compton scattering is entered and carried out to the main detector 1, and since the gamma ray which went into the subdetector 2 and was detected gives a signal pulse to coincidence to subdetector 2 system, a reverse coincidence-counting electronic circuitry distinguishes and removes this. The circuit block diagram of the example of reverse coincidence counting which performs such signal processing is shown in drawing 2 .

[0019] On the other hand, an operation of the thermoelectric-cooling panel 5 is cooling a photoelectric element 3 and keeping at 30 degrees C or less. If 30 degrees C is exceeded, a noise will occur in a photoelectric element 3 and ability to detect will decline. That is, since it can become 40-50 degrees C in the work environment at the time of constant \*\* of a nuclear power plant, it becomes required conditions to cool a photoelectric element 3. It is clear that cooling of a photoelectric element can be extremely attained to a small volume light weight by use of this thermoelectric-cooling panel 5 in this invention.

[0020] Moreover, the radiation shielding objects 9, 10, and 11 shown in drawing 1 are performing the heat dissipation operation of the thermoelectric-cooling panel 5 through the heat transfer plate 6 at the same time they cover a radiation in one. Thus, it is useful to small capacity lightweight-ization to use a screen for heat dissipation. Furthermore, withdrawal and combination can choose the radiation shielding objects 10 and 11 according to a radiation measurement environment with a remarkable degree of freedom.

[0021]

[Effect of the Invention] As explained above, the gamma ray detection equipment of this invention Main-sub \*\*\*\*\* which combined the CsI (Tl) scintillator and the photoelectric element, While surrounding the anticoincidence circuit using these, the thermoelectric-cooling panel which is installed by each above-mentioned photoelectric element and controls the temperature up of each photoelectric element, and the above-mentioned main-sub \*\*\*\*\* and a thermoelectric-cooling panel While using the combination of the CsI (Tl) and the photoelectric element which are equipped with the radiation shielding object which radiates heat in a thermoelectric-cooling panel, and need neither a very-low-temperature cooler style nor a high voltage power supply especially as a detector By adoption of the heat dissipation system using a small lightweight thermoelectric-cooling panel and a radiation shielding object, it is possible lightweight and to form the detection device of an equipment end in a compact. Moreover, the photoelectric element of the above-mentioned CsI (Tl) scintillator can be comparatively used also by hot environments. Furthermore, the Compton background is reduced by the above-mentioned anticoincidence circuit, and if in the measuring power of a gamma ray, remarkable effectiveness that the workability of the radioactivity measurement of a nuclear power plant is improved and promotion of strengthening of this measurement can be aimed at is done so in total.

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**TECHNICAL FIELD**

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[Industrial Application] This invention relates to the energy dispersion mold gamma ray detection equipment which detects radioisotope (nuclear species) by carrying out measurement according to energy of the gamma ray which is a kind of a radiation.

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## PRIOR ART

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[0005] Moreover, the conventional simple detection equipment using said CsI (Tl) detector and photoelectric element was not equipped with the function in which it is an elevated temperature and nuclear species can be identified with a precision sufficient in the work site of the nuclear power plant where the Compton background is high.

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## EFFECT OF THE INVENTION

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[Effect of the Invention] As explained above, it is gamma ray detection equipment of this invention, Main-sub \*\*\*\*\* which combined the CsI (Tl) scintillator and the photoelectric element, While surrounding the anticoincidence circuit using these, the thermoelectric-cooling panel which is installed by each above-mentioned photoelectric element and controls the temperature up of each photoelectric element, and the above-mentioned main-sub \*\*\*\*\* and a thermoelectric-cooling panel While using the combination of the CsI (Tl) and the photoelectric element which are equipped with the radiation shielding object which radiates heat in a thermoelectric-cooling panel, and need neither a very-low-temperature cooler style nor a high voltage power supply especially as a detector By adoption of the heat dissipation system using a small lightweight thermoelectric-cooling panel and a radiation shielding object, it is possible lightweight and to form the detection device of an equipment end in a compact. Moreover, the photoelectric element of the above-mentioned CsI (Tl) scintillator can be comparatively used also by hot environments. Furthermore, the Compton background is reduced by the above-mentioned anticoincidence circuit, and if in the measuring power of a gamma ray, remarkable effectiveness that the workability of the radioactivity measurement of a nuclear power plant is improved and promotion of strengthening of this measurement can be aimed at is done so in total.

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## TECHNICAL PROBLEM

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[Problem(s) to be Solved by the Invention] This invention copes with the actual condition like the above statement and is lightweight and compact, and by finding out the gamma ray detection equipment which can bear an elevated temperature and a high background, the workability of the radioactivity measurement of a nuclear power plant is improved, and it aims at aiming at promotion of strengthening of this measurement.

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MEANS

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[Means for Solving the Problem] Namely, the description of the gamma ray detection equipment of this invention which suits the above-mentioned purpose. The main detector which combined the CsI (Tl) scintillator and the photoelectric element, and the subdetector similarly arranged in the CsI (Tl) scintillator and the photoelectric element so that the perimeter and back of combination and the above-mentioned main detector might be surrounded, While surrounding the thermoelectric-cooling panel which is installed by each above-mentioned photoelectric element and controls the temperature up of each photoelectric element, and the above-mentioned main-sub \*\*\*\*\* and each thermoelectric-cooling panel It is in the place equipped with the radiation shielding object which radiates heat in a thermoelectric-cooling panel, and the electronic circuitry which is made to carry out coincidence detection of the escaping photon of a gamma ray with the above-mentioned main detector and a subdetector, and carries out anticoincidence counting of the pulse from a subdetector to the pulse from the main detector.

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## OPERATION

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[Function] The gamma ray detection equipment of above-mentioned this invention is effective if it utilizes for the periodic check of a nuclear power plant, can measure gamma lineal energy from outsides, such as primary-cooling-system piping of a reactor, in this case, and can presume the amount of the nuclear species inside piping. Furthermore, the effectiveness of washing can be checked, if it measures with the detector by this invention before and after chemical cleaning when chemicals wash the interior of piping at the time of a periodic check.

[0009] Since these measurement is performed during a reactor halt, the temperature and radiation level of work environment are falling to extent which human being puts in, but the piping itself has a case so that measurement may be carried out, when it is in an about 50 degrees C - 100 degrees C condition. Moreover, radiation level has a location-difference by whether the measuring object is a first order system, or it is the second order system, it is piping, or it is a device, and it is necessary to take time change, such as how many hours passed after the reactor halt, into consideration moreover.

[0010] A deer can be carried out and the energy dispersion mold gamma ray detection equipment by above-mentioned this invention can carry out maintenance enhancement of the principle of a small volume light weight corresponding to the location-time difference among these work environments.

[0011] That is, especially in the equipment of above-mentioned this invention, while using the combination of the CsI (Tl) and the photoelectric element which need neither a very-low-temperature cooler style nor a high voltage power supply as a detector, the detection device of an equipment end can be formed in lightweight and a compact by adoption of the heat dissipation system using a small lightweight thermoelectric-cooling panel and a radiation shielding object. moreover, the thing which can act also at temperature with the comparatively

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## EXAMPLE

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[Example] With reference to an accompanying drawing, the example of this invention is explained further below.

[0013] It is one example of this invention which is shown in drawing 1 , and it is the example of the gamma ray detection device considered for applying to the periodic check of a nuclear power plant. The detection equipment of this example is equipped with the electronic circuitry of reverse coincidence counting shown in the gamma ray detection device and drawing 2 of the equipment end shown in drawing 1 , and die length is [ the diameter of the outline dimensions of the above-mentioned gamma ray detection device ] about 10cm in about 13cm.

[0014] First, the structure of radiation detection and cooling is explained. In drawing, 1 is the core mold CsI(Tl) main detector, the quality of the material makes the single crystal of CsI (Tl) the scintillator to a gamma ray, and equips the end face with the silicon photodiode of a photoelectric element 3, and generates an electrical signal. Although 2 is similarly a CsI (Tl) detector, the configuration serves as a subdetector of the well mold which encloses the perimeter and back of the above-mentioned main detector 1. The electrical signal which comes out of these detectors 1 and 2 goes into each preamp substrate 4, and goes to the anticoincidence circuit shown in drawing 2 .

[0015] On the other hand, the thermoelectric-cooling panel 5 of known structure is stuck on the photoelectric element 3, and the temperature of a photoelectric element 3 can be cooled at 30 degrees C or less.

[0016] Next, radiation shielding and many structures of heat dissipation are explained. The radiation shielding objects 9, 10, and 11 are leaden barrels, and serve as the operation which radiates heat in the heat of the thermoelectric-cooling panel 5 of 5 through the heat transfer plate 6. Between the heat transfer plate 6 and the radiation shielding object, the good indium foil 7 of

heat conduction is stuck. The radiation shielding objects 10 and 11 can attain lightweight-ization further by desorption being possible and removing these with the reinforcement of environmental radiation, in the case of a low-dose rate.

[0017] In addition, a hole for the collimator for detection in 12 in drawing and 13 to pull out wiring (not shown) to the exterior and 8 show the heat-insulating element, respectively.

[0018] Furthermore, it explains below what kind of operation the structure shown in drawing 1 has achieved. a scintillator -- the core mold CsI(Tl) main detector 1 and the well mold CsI(Tl) secondary detector 2 -- dividing -- the end face -- the each photoelectric element 3 (photodiode) -- equipping -- each electrical signal -- two preamp substrates 4 -- drawing and both signals -- receiving -- anticoincidence -- counting -- a method is applied. This reverse coincidence counting pulls out only a photograph peak vividly except for the noise by Compton scattering of a gamma ray spectrum, and is known as the technique of raising the spectral sensitivity of a detector. The structure shown in drawing 1 has the description fundamental to the point which enabled it to apply this technique according to the structure of a very small volume light weight. Compton scattering is entered and carried out to the main detector 1, and since the gamma ray which went into the subdetector 2 and was detected gives a signal pulse to coincidence to subdetector 2 system, a reverse coincidence-counting electronic circuitry distinguishes and removes this. The circuit block diagram of the example of reverse coincidence counting which performs such signal processing is shown in drawing 2 .

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[0020] Moreover, the radiation shielding objects 9, 10, and 11 shown in drawing 1 are performing the heat dissipation operation of the thermoelectric-cooling panel 5 through the heat transfer plate 6 at the same time they cover a radiation in one. Thus, it is useful to small capacity lightweight-ization to use a screen for heat dissipation. Furthermore, withdrawal and combination can choose the radiation shielding objects 10 and 11 according to a radiation measurement environment with a remarkable degree of freedom.

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## DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]

[Drawing 1] It is the sectional view showing the detection device of the gamma ray detection equipment of this invention example.

[Drawing 2] It is the circuit block diagram of reverse coincidence counting of this example.

[Description of Notations]

- 1 The Main Detector (CsI (Tl) Scintillator)
- 2 SubDetector (CsI (Tl) Scintillator)
- 3 Photoelectric Element
- 4 Preamp Substrate
- 5 Thermoelectric-Cooling Panel
- 6 Heat Transfer Plate
- 7 Indium Foil
- 8 Heat-insulating Element
- 9, 10, 11 Radiation shielding object

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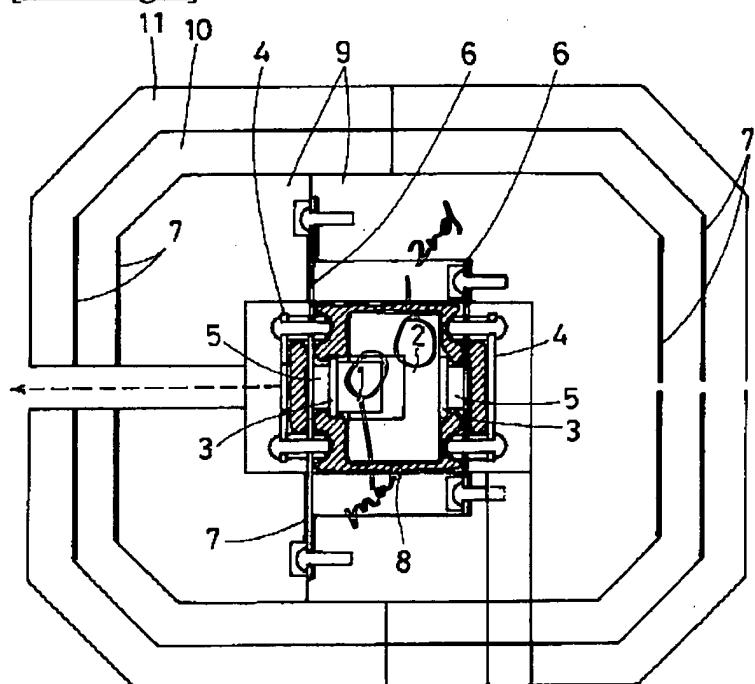
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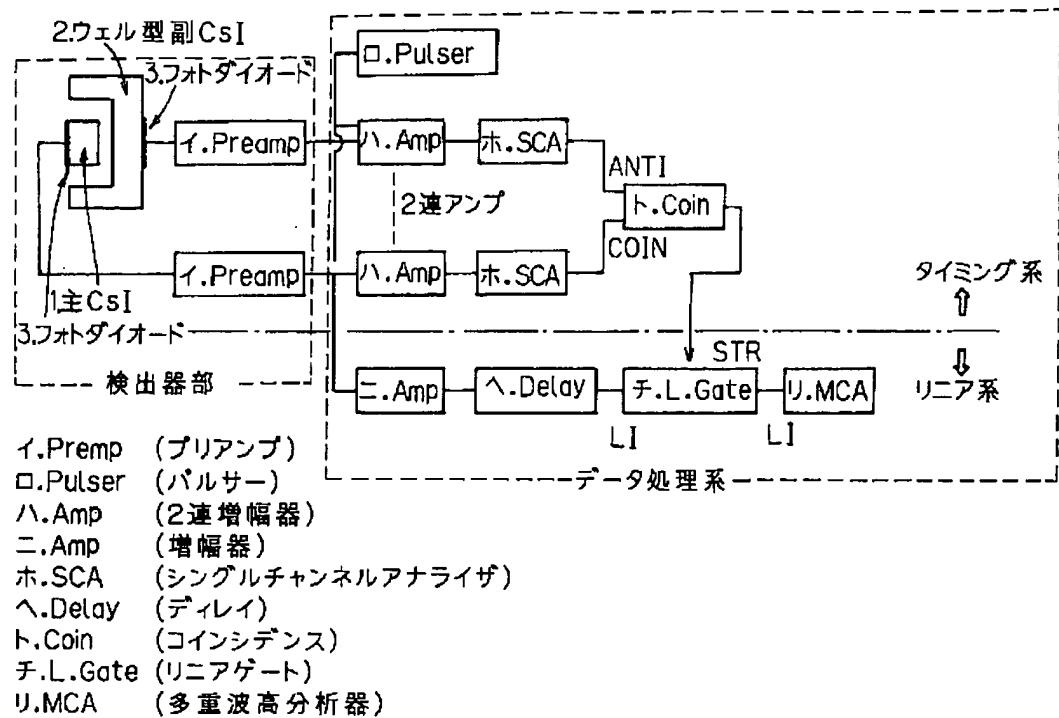
DRAWINGS

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[Drawing 1]



[Drawing 2]



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